

Waking conscious states and offline memory processing

ABSTRACT:

Background

Accumulating evidence suggests that moments of inattention to our surroundings may be essential to optimal cognitive functioning.

Aims

We investigated the hypothesis that humans spontaneously switch between two opposing attentional states during wakefulness – one in which we attend to the external environment (an “online” state) and one in which we disengage from the sensory environment to focus our attention internally (an “offline” state). We hypothesized that memory consolidation is facilitated by entry into the “offline” state.

Method

Across two studies, we detected entry into the “offline” state during a ~30min period of wakefulness. Participants completed a verbal learning task and then underwent simultaneous high density EEG and pupillometry recording, and intermittently reporting on their subjective experience. “Online” and “offline” attentional states were defined using a cluster analysis applied to multimodal measures of 1) EEG spectral power, 2) pupil diameter, 3) reaction time (RT), and 4) self-reported subjective experience.

Using a machine-learning classification approach, we determined the amount of time that participants spent in an offline state after learning, and tested whether this predicted memory for the verbal information encoded at the start of the study.

Results

We report evidence of statistically discriminable “online” and “offline” states matching the hypothesized characteristics. In both studies, the offline state predicted memory retention for previously-encoded verbal information.

Conclusions

Together, these observations suggest that seconds-timescale alternation between online and offline states is a fundamental feature of wakefulness, and that this may serve a memory processing function.

Keywords

Memory consolidation, Electroencephalography, Pupillometry, Mind wandering, Daydreaming, Offline memory processing, Machine learning

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Published Work:

Wamsley, E., & Summer, T. (2020). Spontaneous entry into an “offline” state during wakefulness: A mechanism of memory consolidation? *Journal of Cognitive Neuroscience*, 32(9), 1714-1734. doi: 10.1162/jocn_a_01587

Wamsley, E. J. (2019). Memory consolidation during waking rest. *Trends in Cognitive Sciences*, 23(3), 171-173. doi: 10.1016/j.tics.2018.12.007

Researcher's Contacts:

Erin J. Wamsley
Associate Professor
Furman University
Department of Psychology and Program in Neuroscience
Johns Hall 206K
Tel: 864-294-3218
Email: erin.wamsley@furman.edu
<http://www.furmansleeplab.com/>